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RESEARCH MEMORANDUM

EFFECT ON TRANSONIC AND SUPERSONIC DRAG OF FUSELAGE GLOVES DESIGNED TO GIVE A SMOOTH OVERALL AREA DISTRIBUTION TO A SWEPT-WING—BODY COMBINATION

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RESEARCH MEMORANDUM

EFFECT ON TRANSONIC AND SUPERSONIC DRAG OF FUSELAGE GLOVES DESIGNED TO GIVE A SMOOTH OVERALL AREA DISTRIBUTION TO A SWEPT-WING—BODY COMBINATION

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SUMMARY

A free-flight investigation into the effect of fuselage gloves, or local increases in volume, designed to improve the overall longitudinal area distribution of a swept-wing—body combination revealed that a reduction of about 20 percent in maximum pressure drag was obtained. The drag reduction effected by the use of gloves decreased with increasing Mach number, becoming zero at a Mach number of about 1.35, the limit of the experiments.

INTRODUCTION

The possibility of reducing configuration drag by adding fuselage volume in the form of a glove to give a favorable overall area distribution is a natural extension of the area rule promulgated in reference 1. The theoretical computations of reference 2 indicate the possibility of drag reduction through addition of fuselage volume. In the experiments of references 3 and 4, pressure-drag reductions of as much as 30 percent were attained by the addition of gloves to the delta-wing and unswept-wing configurations tested. Other unreported wind-tunnel experiments substantiate the possibility of reducing drag by adding fuselage volume to improve the overall area distribution.

The purpose of the current tests is to show the drag benefits, if any, to be derived from the addition of fuselage gloves to a 45° swept-wing—body combination.

SYMBOLS

A	cross-sectional area of equivalent body
C_D	drag coefficient, $\dfrac{D}{\frac{\rho}{2} V^2 S}$
ΔC_D	pressure-drag coefficient, $C_D - C_{D_{subsonic}}$
l	fuselage length, 56 in. (reference length for nondimensionalizing the subject area distributions)
M	Mach number
R	Reynolds number
r	radius of equivalent bodies
S	exposed wing area, 2.0 sq ft
V	velocity, ft/sec
x	distance from nose to fuselage station, in.
ρ	density of air, slugs/cu ft

MODELS AND TEST PROCEDURE

The general arrangement of the models and the model coordinates are shown in figure 1. Model photographs are shown in figure 2, and the longitudinal area distributions appear in figure 3. The models were identical except for the addition of a fiber-glass glove to the fuselage of model 2, which provided the volume necessary to give a favorable over-all area distribution to the model. The additional volume is shown as the shaded portion of figure 3. The maximum increase in fuselage radius required to provide this additional volume was 0.20 inch. The increased radius represents an increase of 17 percent in maximum cross-sectional area of the fuselage. The total increase in fuselage volume due to the gloves was 7 percent.

The models employed a constant-thickness 45° swept wing of hexagonal section. The thickness ratio was 0.052 at the tip and 0.029 at the root. The taper ratio was 0.56 and the aspect ratio was 3.3. The 5-inch-diameter fuselage was of fineness ratio 11.2 with a nose fineness ratio of 3.5 and an 8° conical boattail. Constant-thickness vertical tail fins with beveled edges were used. The models were constructed of 24S-T aluminum alloy.

The models were accelerated to supersonic velocities by a 5-inch HVAR booster and a 3.25-inch Mk 7 aircraft rocket motor carried internally. A photograph of a model and booster on the launching stand is shown in figure 4.

The models carried no internal instrumentation, but were tracked by SCR 584 radar to give a flight-path history and by Doppler velocimeter to give a velocity history. A survey of atmospheric temperature, pressure, humidity, and wind was provided by a radar-tracked radiosonde released at the time of the launching. The model drag coefficient was determined from the above information by the method described in reference 5.

The Reynolds number range of the tests based on the wing mean aerodynamic chord varied from 7.5×10^6 at a Mach number of 1.35 to 3.3×10^6 at a Mach number of 0.75.

The probable maximum errors of the results are as follows:

C_D . . . . ± 0.0015
M . . . . ± 0.005

The measured drag and pressure drag of the experimental models are shown in figure 5. It can be seen that the use of fuselage gloves to provide a favorable overall area distribution resulted in a reduction in maximum pressure drag of 0.0045, or about 20 percent. The reduction persisted with decreasing magnitude up to a Mach number of 1.35, the extent of the measurements. The supersonic body-plus-fin drag from reference 6, and the subsonic body-plus-fin drag from reference 7 corrected for two fins and decreased base diameter, are shown in figure 5. Note that the addition of gloves eliminates a large percentage of the pressure-drag increment due to the wings at a Mach number of 1.05. The effectiveness of the gloves diminishes to zero near a Mach number of 1.35 and, extrapolating, would produce a higher drag beyond a Mach number of 1.35. This result is in agreement with those of reference 8 wherein tests of indented sweptback wing-body combinations with smooth transonic area distributions had adverse drag effects at Mach numbers beyond the low-supersonic range.

A comparison of the maximum pressure drag for the test models calculated by the method of reference 9 is shown in figure 5. The calculated level is considerably different from the measured level of pressure drag, but the calculated increment due to the gloves agrees fairly well with the measured increment. On the basis of these calculations, the rear glove is about twice as efficacious as the forward glove in reducing the drag of the wing-body combination.

Mention might be made of the results of reference 10, wherein an unswept wing with a rapid rate of change of area at the trailing edge was tested on a fuselage identical to the fuselage of the present investigation. The use of a single glove behind the wing effected no improvement in drag, probably because of the high surface slopes required on the glove and the fact that only one glove was used. Experiments described in reference 4 concern the use of gloves with an unswept wing of moderate taper; a reduction in drag of about 30 percent was effected by the use of gloves, the slopes of which were only about half as severe as those in reference 10.

It may be concluded from the present tests and those reported in references 3 and 4 that reductions in pressure drag at transonic and low-supersonic speeds may be effected by the addition of gloves to a fuselage combined with straight, swept, or delta wings.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., August 18, 1954.

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Fus.Sta.	Fuselage Radius	
	Model 1	Model 2
0	0	0
1	.250	.250
2	.480	.480
3	.710	.710
4.25	.975	.975
5	1.130	1.130
7.5	1.570	1.570
10	1.955	1.955
12.50	2.252	2.252
15	2.429	2.420
16.35	---	2.470
17.50	2.500	---
18	↓	2.530
20		2.600
22		2.630
24		2.680
26		2.700
28		2.660
30		2.610
34		2.500
36		2.500
38		2.510
40		2.570
42		2.650
44		2.720
45		2.700
46		2.670
48		2.590
50.22	2.500	2.500
56	1.687	1.687

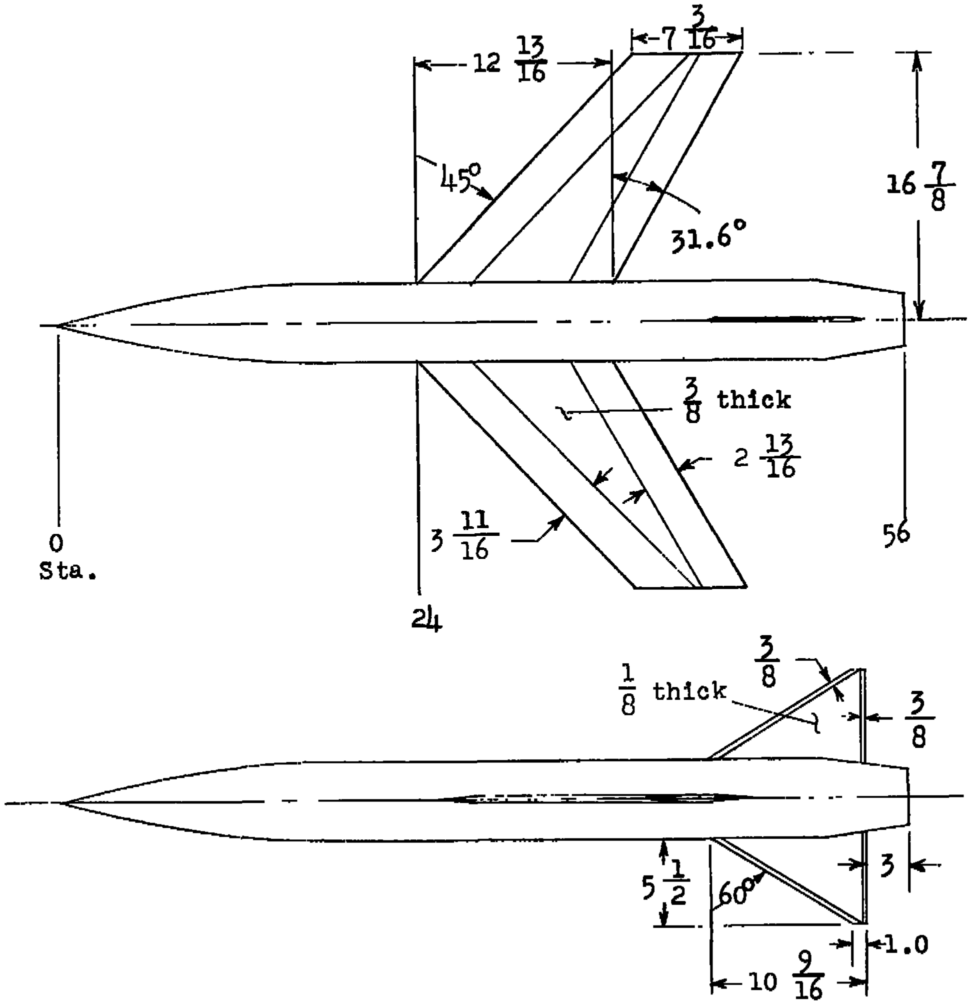
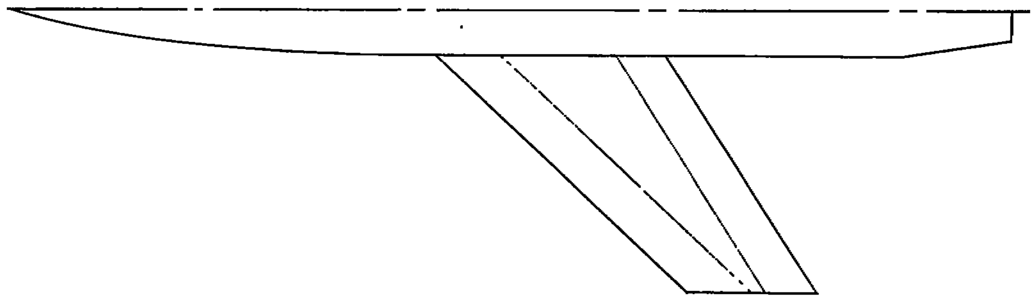


Figure 1.- General arrangement of the test vehicles. Model 1 is identical to model 2 except for addition of fuselage gloves to model 2. All dimensions are in inches.

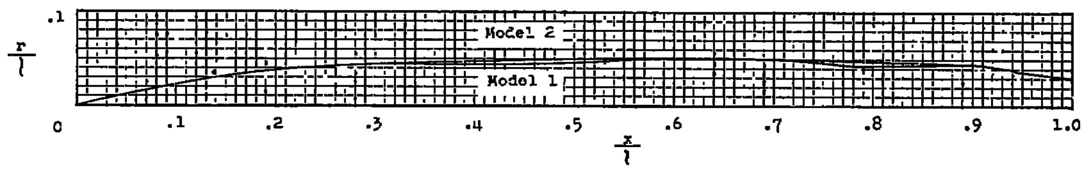
(a) Model 1. L-83058.1

(b) Model 2 showing fuselage gloves. L-83055.1

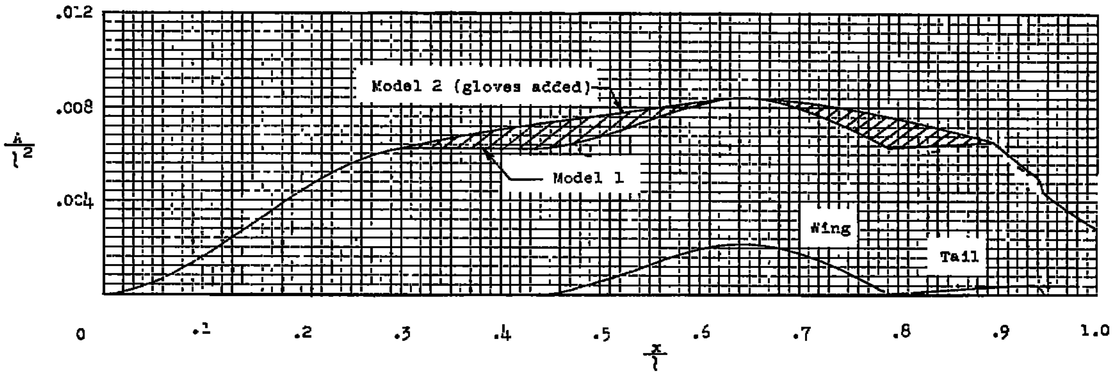
Figure 2.- Photographs of the test vehicles.



(a) Plan view of model 1.



(b) Radius distribution.



(c) Area distribution.

Figure 3.- Plan view of model 1, and nondimensional area distribution and radius distribution of both models.

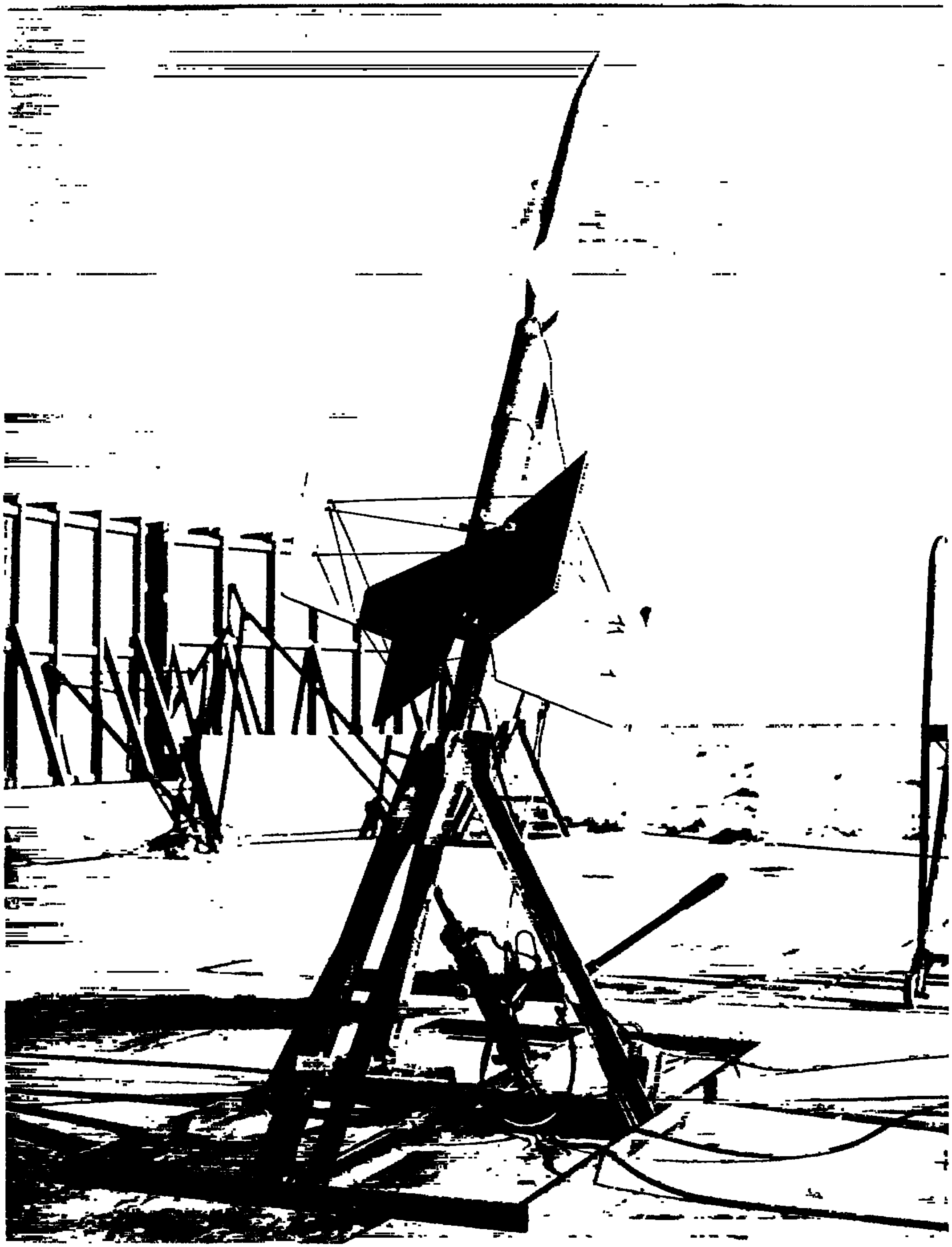


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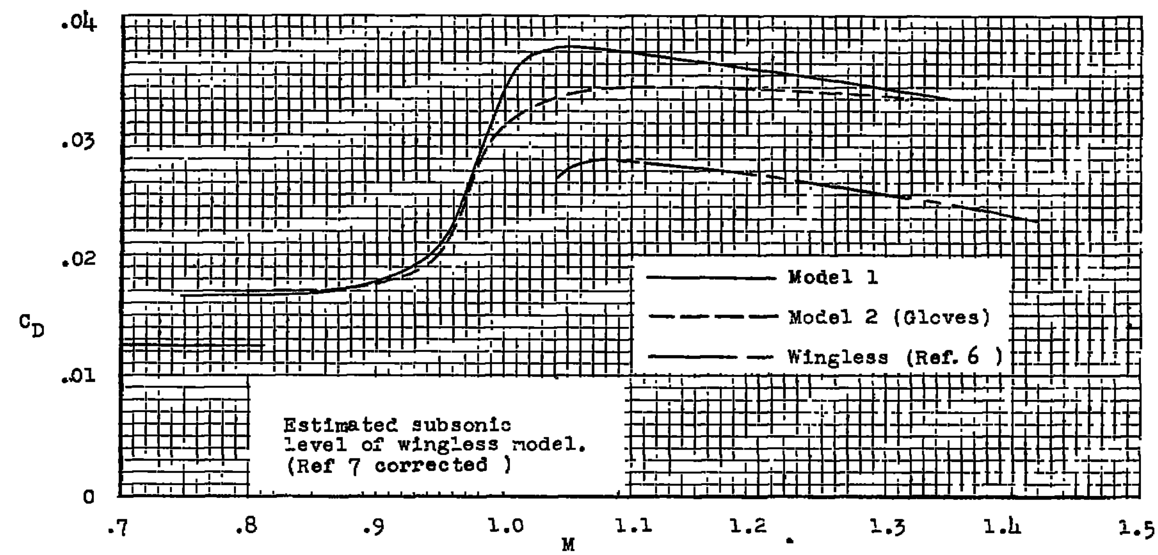
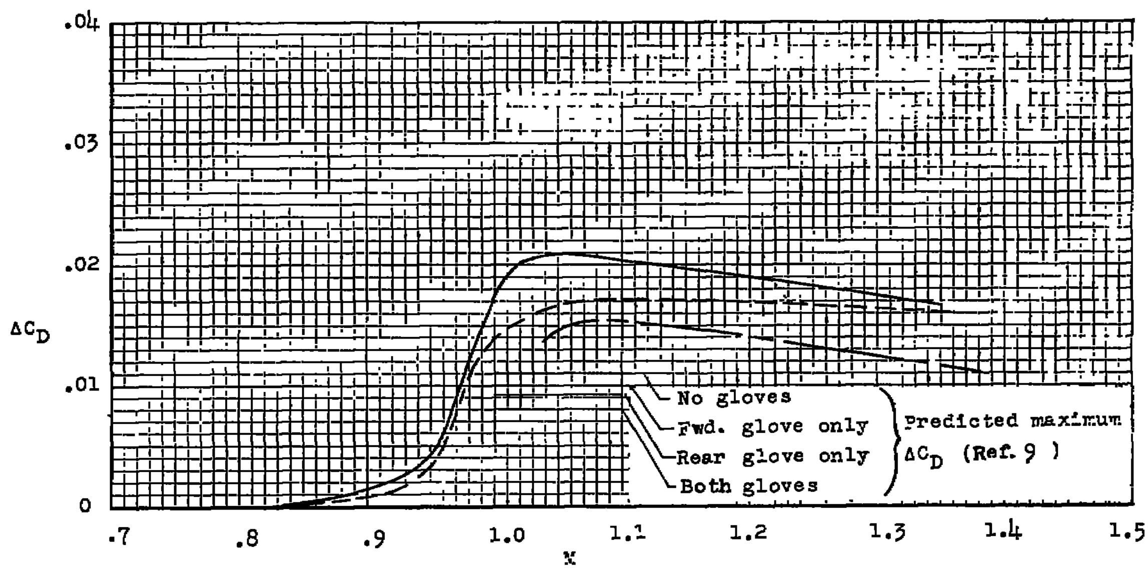
Figure 4.- Typical model and booster on launcher just prior to firing.



(a) Drag-coefficient variation.



(b) Pressure-drag-coefficient variation.

Figure 5.- Drag-coefficient and pressure-drag-coefficient variation with Mach number.

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